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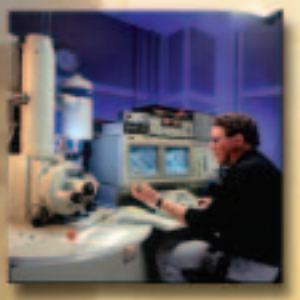
Transitions To A New Energy Future



Twenty-eight years ago, the first oil embargo was a rude awakening to our vulnerability to energy supply disruptions. But that oil embargo spurred Congress to create the Solar Energy Research Institute—designated a national laboratory and renamed the National Renewable Energy Laboratory in 1991—to help develop the technology to make it possible to achieve a transition to a new energy future.

What has happened since SERI/NREL first began operating 25 years ago? America uses nearly 50% more renewable energy than it did then. We are witnessing the emergence of markets based on new energy technologies. America is employing energy efficiency on a grander scale, decreasing its energy intensity (energy used per dollar of gross domestic product) by about 1% per year.

Yet, today America is more dependent on foreign oil than ever. We use more natural gas and 75% more coal than we did in 1977. Driven largely by economic growth, our energy consumption has jumped by about 23 quads (where one quad equals 10^{15} Btus), with less than 3 quads of that increase coming from renewable energy. This has resulted in large increases in greenhouse gas emissions and in air pollutants.

In light of these facts, is it still possible to achieve sustainable energy use? Yes—in the long run. We must remember that it took 50 years from the building of the first oil refinery until oil provided 10% of America's energy mix, and 60 years for natural gas to do likewise.

In the short term, with a portfolio of new energy technologies and an enlightened public policy, we will produce incremental changes. But these changes will, working with the existing energy infrastructure, begin to build exponentially to become significant in two, three, or four decades. And in the long term, what started as small changes will grow to become a paradigm shift in how America uses energy.

At the heart of this shift will be technology. And at the heart of the technology will be NREL. For the past 25 years, NREL has helped build a foundation of renewable energy and energy efficiency science and technology to put sustainable energy use within reach. For the next 25 years and more, NREL will remain at the technology forefront to spur various transitions toward sustainable energy. This silver anniversary first biennial *2002 Research Review* lays out a series of key transitions that will allow us to move toward a sustainable world and indicates ways in which NREL and its partners are making that possible.

Wind and solar electricity markets, for example, are growing at rates greater than 30% per year. With help from advances such as NREL's advanced airfoil designs, wind power is already nearly competitive with some fossil-fuel main-

The 2002 Research Review

This Silver Anniversary *2002 Research Review* is intended as the first in a series of biennial overview reports on research progress at NREL. These reports will become part of a series of semiannual journals, with the regular journal issues exploring particular NREL research efforts in depth.

grid electricity generation. With potential in the Great Plains alone to generate all of America's electrical needs, wind power could soon become a major energy contributor, especially as we develop the technology that enables wind turbines to produce competitive electricity in low-wind-speed regimes.

As the solid-state approach to converting solar energy to electricity, photovoltaic (PV) solar cells are the epitome of "futuristic" energy and are the best choice for high-tech applications such as communications satellites and space shuttles. They also are becoming a preferred choice for remote applications, for distributed generation, and for applications in which PV can be integrated directly into the façade or structure of buildings. NREL's research on innovative concepts that could help drop costs significantly also could make solar electricity a preferred choice for main-grid power in another couple of decades.

But the future could easily bring a move away from reliance on main-grid power or even electricity as the only energy carrier. New modular technologies (small gas turbines, fuel cells, solar cells, wind turbines, bioelectricity) and market needs—such as high-quality power for high-tech companies—have created opportunities for electrical generation at the user site. In the section on distributed energy resources, we explain how NREL works on improving the institutional as well as the technological ability to integrate these distributed energy resources with the electrical generation system.

Hydrogen, like electricity, is easy to transport and burns cleanly, so makes a great energy carrier. And because hydrogen can be produced and used as part of a clean, cyclic process when generated with a renewable source, it represents one of our most promising paths toward a sustainable energy future. In the section on the hydrogen economy, we describe several technologies that NREL researchers are exploring to cleanly and efficiently produce hydrogen with renewable energy.

When it comes to reducing vulnerability to dependence on foreign oil, it is vitally important to develop alternative transportation fuels. NREL leads efforts to develop technology to produce fuel ethanol from lignocellulosic biomass—the bulk of most plant materials. In the section on biorefineries, we describe how this technology and five other core biomass technologies can be used not only to produce fuel but also to make plastics, fibers, and other products now derived from chemicals produced at oil refineries from petroleum. These six biomass technologies are the platforms from which we can build the biomass economy and the biorefinery concept into a significant presence.

Hand-in-hand with research on fuels and products from biorefineries goes NREL's research on transportation technologies. This includes research to make transportation vehicles cleaner and more efficient, from "cool cars" that save on air-conditioning, to clean diesel engines and designer fuels, to vehicles that run on alternative fuels, to hybrid electric vehicles. All of which will help reduce demand for foreign oil.

And last but not least, as with money, the best way to make energy is to save energy. In the section on energy-efficient buildings, we describe a whole-building design approach, and a variety of technologies such as solar heating, natural daylighting, and building-integrated photovoltaics that NREL is developing to reduce energy use in homes and commercial buildings. Efficient design and modern technology will enable us to develop zero-energy buildings—where a building's energy use will be reduced to zero—an attainable goal for homes built during the next 25 years.

Each of these energy transitions will be important in its own right and will contribute to America's economy and to its path toward greater energy security. But taken together, they represent a formidable force that could pave the way to a new energy paradigm and a truly sustainable energy future.

25 Years of Research Excellence 1977-2002

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